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Vol. 97 SEPTEMBER 26, 1942 No. 7

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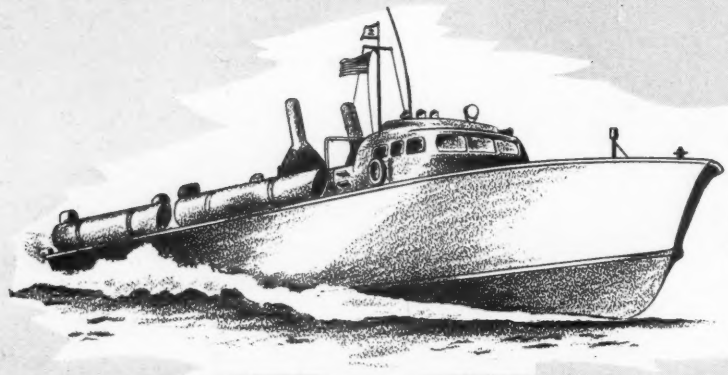

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AMERICAN FERTILIZER

"That man is a benefactor to his race who makes two blades of grass to grow where but one grew before."

Vol. 97 SEPTEMBER 26, 1942 No. 7

Nutrient Value of Some New Phosphatic Materials Used on Potatoes

By G. V. C. HOUGHLAND[1], K. G. CLARK[2], ARTHUR HAWKINS[3], AND JOHN C. CAMPBELL[4]

POTATO growers today are as a rule thoroughly "fertilizer conscious;" that is, they realize the economic advantages that may be gained by keeping the yield per acre as high as possible and have become familiar with the part played by the proper use of fertilizer in doing this. Especially is this true of growers in the eastern States where rates of fertilizer application of from 1,800 to 2,000 pounds per acre are commonly used for potatoes in many sections of the Coastal Plain Area, even reaching 2,500 pounds under some circumstances.

Although the percentage of nitrogen and of potash in the potato fertilizer may vary somewhat according to the location and variety grown, the percentage of phosphoric acid contained is quite uniform, usually amounting to 8 per cent of the mixture and only occasionally exceeding 10 per cent. Applied at a ton per acre these fertilizers would supply 160 and 200 pounds of phosphoric acid per acre, respectively. When the phosphoric acid is supplied by 20 per cent superphosphate, each ton of these fertilizers contains, respectively, 800 and 1,000 pounds of superphosphate.

From these considerations it is not difficult to assess the importance of superphosphate to the potato grower. It is estimated that throughout the country approximately 540,000 tons of single-strength fertilizer containing some 240,000 tons of ordinary superphosphate are used annually on the potato crop.

This paper reports the results of field experiments conducted in cooperation with the Maine, New Jersey, and Pennsylvania Agricultural Experiment Stations to determine the relative nutrient value of: (1) calcium metaphosphate, (2) calcined phosphate, (3) dicalcium phosphate, (4) fused phosphate, (5) monocalcium chlorophosphate, (6) potassium metaphosphate, and (7) triple superphosphate in comparison with ordinary superphosphate when used in complete fertilizer on the potato crop.

Materials

The composition, particle size, and source of the several phosphates tested are given in Table 1.

Potassium metaphosphate, KPO_3, is outstanding among these materials from the standpoint of high plant-food concentration since, except for impurities, it consists entirely of potash (K_2O) and phosphoric acid (P_2O_5). Theoretically, the pure metaphosphate contains 39.87 per cent K_2O and 60.13 per cent P_2O. Furthermore, the most readily prepared form of this metaphosphate is soluble only to the extent of about 1 part in 25,000 parts of water (40 p.p.m.) at room temperature (*1*)* Although almost insoluble in cold water it hydrolyzes slowly to the orthophosphate in warm water. A 2.5 gram sample completely dissolves in half an hour in the boiling ammonium oxalate solution

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*Numbers in parenthesis refer to literature listed at the end of the article.

prescribed by the Association of Official Agricultural Chemists for the determination of available potash in mixed fertilizers. Considerable difficulty, however, is usually experienced in determining the citrate-insoluble phosphoric acid content by the official method since it is practically impossible to filter and wash the citrate-insoluble residue within a reasonable time.

The potassium metaphosphate used in these experiments was prepared by dehydration of a technical grade of primary potassium orthophosphate. The major portion of the combined water was released below 300° C., but heating was continued at 600° C. to complete dehydration and insure a uniform product.

Potassium metaphosphate might be prepared for fertilizer use by reacting phosphoric acid and muriate of potash (*1*) in a furnace similar to that used for the production of salt cake from salt and sulphuric acid, or by a process like that under development by the Tennessee Valley Authority (*2*) in which the hot products of combustion of elemental phosphorus and moist air are brought into contact with the muriate in a combination shaft and hearth furnace. In either case hydrochloric acid would be a by-product that could be utilized in the production of dicalcium phosphate or monocalcium chlorophosphate.

Calcium metaphosphate ranks next to potassium metaphosphate in total plant-food concentration, but exceeds the latter in phosphoric acid content. The pure calcium salt contains 71.68 per cent P_2O_5. A crude vitreous product that contains 64 per cent or more P_2O_5 has been produced for several years by the Tennessee Valley Authority (*2*) by burning phosphorus in air and bringing the hot products of combustion into contact, with lump rock phosphate or phosphate sand. Over a period of nine months operation the product is reported to have averaged 65.5 per cent P_2O_5. It is almost completely soluble in ammonium citrate solution, but nearly insoluble in cold water if the CaO to P_2O_5 ratio exceeds the theoretical value, and quite soluble if the P_2O_5 is in excess.

Crude dicalcium phosphate is commonly produced as a by-product in the manufacture of gelatin from bones. This phosphate is precipitated when the solution resulting from the digestion of bones in dilute hydrochloric acid is neutralized with milk of lime. The dicalcium salt also may be produced from rock phosphate and hydrochloric acid by a similar solution and precipitation process, but the product usually contains a somewhat greater amount of fluorine than when produced from bone. It also may be produced from lime, or limestone, and phosphoric acid. The material used in these experiments was produced on an experimental basis by the Tennessee Valley Authority.

Calcined phosphate currently refers to the low-fluorine sintered product obtained by heating phosphate rock in the presence of water vapor at approximately 1,400° C. The material used was supplied by the manufacturer from a lot produced experimentally in an oil-fired rotary kiln.

Fused phosphate rock is prepared by defluorinating molten rock phosphate with water vapor, usually at about 1,550° C. The material used was produced on an experimental basis by the Tennessee Valley Authority.

Pure monocalcium chlorophosphate,

TABLE 1—PHOSPHATIC MATERIALS USED IN FIELD EXPERIMENTS

Material	P_2O_5	
	Total	Citrate-insoluble
Ordinary superphosphate[1]	19.3	....
Calcium metaphosphate[2, 3]	59.4 to 63.1	....
Calcined phosphate[4]	36.24 to 37.29	3.73 to 5.86
Dicalcium phosphate[2, 5]	47.8	0.6
Fused phosphate[2, 6]	30.5	....
Monocalcium chlorophosphate[7, 8]	33.35 to 34.92	0.37 to 1.22
Potassium metaphosphate[7, 9]	59.89 to 60.38	2.47[10]
Triple superphosphate[2]	48.7	....

[1] Standard commercial product.
[2] Supplied by Tennessee Valley Authority.
[3] 42.5 per cent 50 to 100 mesh.
[4] Experimental product supplied by manufacturer. Ground to pass 60 or 80 mesh.
[5] 14.3 per cent 10 to 20 mesh; 62.6 per cent 20 to 60 mesh.
[6] 10.7 per cent 50 to 100 mesh; 16.3 per cent 100 to 150 mesh.
[7] Supplied by Division of Soil and Fertilizer Investigations, Bureau of Plant Industry, U. S. Department of Agriculture.
[8] Contained 27.48 to 31.30 per cent water-soluble P_2O_5 and 13.26 to 15.03 per cent Cl; 38.9 per cent 10 to 35 mesh, 27.8 per cent < 100 mesh.
[9] Contained 39.52 to 39.77 per cent K_2O. Ignition loss 0.33 to 0.42 per cent at 700° C; 9.1 per cent 20 to 35 mesh, 62.0 per cent < 100 mesh.
[10] Washing with water after the citrate solution was filtered off was extremely difficult and required about 20 hours.

$CaClH_2PO_4.H_2O$, contains 37.25 per cent P_2O_5 (*3, 4*). The crude material used in these experiments was prepared by treating various grades of Florida pebble phosphate and Tennessee brown-rock phosphate with hydrochloric and phosphoric acids. Hydrochloric acid (20° Bé., 31.5 per cent HCl) was added to finely ground raw rock to produce a mixture in which the chlorine was equivalent to approximately one-half the calcium. After completion of the initial reaction with the acid and while the mixture still was in a fluid condition 75 per cent phosphoric acid was added to adjust the CaO/P_2O_5 ratio to that required by the above formula for chlorophosphate. Mixing was continued for a few minutes until the mixture thickened. The solidified mass was then broken into lumps and dried either at about 100° C. under reduced pressure, or by exposure to the air at room temperature.

Preparation of crude chlorophosphate as outlined above avoids the formation of any significant amount of free calcium chloride in the product, and in many respects is similar to the manufacture of superphosphate. This use of hydrochloric acid is equivalent, in the case of a rock with a CaO to P_2O_5 mol ratio of 3.5, to replacing with hydrochloric acid 70 per cent of the phosphoric acid that would be required to produce triple superphosphate. The P_2O_5 concentration of the chlorophosphate is intermediate between the superphosphate made with sulphuric acid and that made with phosphoric acid. Although the chlorine content of chlorophosphate is relatively high, it should be pointed out that mixtures of this material and high-grade muriate of potash which do not have P_2O_5 to K_2O ratios greatly in excess of 2 will have lower Cl to K_2O ratios than corresponding mixtures of superphosphate and manure salt.

The triple superphosphate used was made from rock phosphate and phosphoric acid by the Tennessee Valley Authority.

Field Results

The results obtained on Caribou loam in Aroostook County, Maine, covering a period of four seasons, are given in Table 2. In 1938 and 1939 the experiment was conducted on two farms for which separate results are given. The fertilizers used were 4–8–7 mixtures with the phosphoric acid in each case supplied by one of the phosphatic materials listed in the table. In formulating all mixtures used in these experiments the phosphatic materials were always added in amounts supplying equal quantities of total phosphoric acid. Application in the field was made at the rate of 2,000 pounds per acre in two bands placed 2 inches to the sides and at or slightly below the level of the seed piece. Green Mountain variety was grown from certified seed in all the Maine experiments.

From the standpoint of yields produced in Maine, perhaps the most outstanding phosphatic material was potassium metaphosphate. With the exception of 1936, the yields from this material either closely matched or exceeded those obtained with superphosphate. It cannot be stated, however, that these results were due entirely to the phosphorus source alone. The potassium metaphosphate mixtures supplied almost no calcium, approximately 24 per cent of the potassium as muriate, and one-sixth to one-fourth as much chlorine as the other mixtures. Varied responses were obtained from the other phosphatic materials tested

TABLE 2—EFFECT OF DIFFERENT PHOSPHATES ON YIELD OF POTATOES DURING 4 YEARS IN MAINE

Caribou loam, 4–8–7 fertilizer mixture, 1 ton per acre

Source of phosphoric acid in fertilizer mixture	Average yield per acre					
	1936 Bu.[1]	1937 Bu.[2]	1938 Bu.[1]		1939 Bu.[2]	
			Farm No. 1	Farm No. 2	Farm No. 1	Farm No. 2
Ordinary superphosphate	520	483	390	330	224	279
Calcium metaphosphate	483	459	348	304	202	262
Calcined phosphate	507	489	326	299	204	253
Dicalcium phosphate	488	454	349	337	200	249
Fused phosphate	455	445	341	315	202	283
Monocalcium chlorophosphate (with KCl)	456	473	327	326	217	271
Monocalcium chlorophosphate (with K_2SO_4)	494	482	344	364	221	274
Potassium metaphosphate	480	487	383	347	223	277
Triple superphosphate	464	461	369	330	219	264
No phosphorus (4–0–7)	465	429	297	319	147	224

[1] Average 4 replications.
[2] Average 6 replications.

in Maine. Although many of the yields were less than those obtained with ordinary superphosphate, yet there was no definite indication that the potato crop was unable to utilize phosphoric acid supplied by these new phosphatic materials. Triple superphosphate, it will be noted, also gave reduced yields, being lower than ordinary superphosphate in five of the six tests compared. In the case of monocalcium chlorophosphate two mixtures were prepared, one with muriate and one with sulphate of potash. This was done to determine whether the higher chlorine content of the muriate of potash would prove injurious. The muriate-chlorophosphate mixture contained three times as much chlorine as the sulfate-chlorophosphate mixture, and one and one-half times as much as the other mixtures in which muriate was the principal source of potassium. Yields of the sulfate of potash mixture were higher every year, apparently indicating a slight superiority for this combination.

The studies as conducted in Maine furnish results indicating that the potato crop apparently was able to utilize phosphorus from all of these materials readily under Maine conditions since, with the exception of fused phosphate, the yields from the materials tested exceeded those of the no-phosphorus treatment in at least five out of six tests. Ordinary superphosphate, dicalcium phosphate, monocalcium chlorophosphate with potassium sulphate, and potassium metaphosphate produced greater yields than the no-phosphorus treatment in every instance. Potassium metaphosphate produced greater yields than ordinary superphosphate in two cases; while only calcium metaphosphate, monocalcium chlorophosphate with potassium chloride, and triple superphosphate failed to produce greater yields than ordinary superphosphate at least once.

A similar study of phosphoric acid materials was conducted on Sassafras loam near Cranbury, New Jersey, in 1937 and 1939. In these experiments 4–8–8 fertilizers, each containing a single source of phosphoric acid, were applied in bands at each side of the seed-piece at the rate of 2000 pounds per acre. Certified Irish Cobbler seed was planted both years. In 1937 owing to a shortage of materials the experiments included only three of the newer sources of phosphoric acid. The results obtained are presented in Table 3.

The results obtained in New Jersey with the different phosphatic materials bear a close relationship to those obtained in Maine. None of the materials appeared to be injurious, all giving satisfactory yields in comparison with the yield obtained from superphosphate. It is interesting to note that monocalcium chlorophosphate used with sulphate of potash again gave slightly higher results than a similar mixture with muriate of potash, although the increases are not regarded as significant. The results for 1939 are perhaps of doubtful significance owing to an apparent lack of response to phosphorus as indicated by the yield from 4–0–8 fertilizer.

Comparison of phosphatic materials were made in Pennsylvania on Berks shale loam northwest of Allentown from 1938 to 1941, inclusive.[5] The phosphatic materials com-

[5] In connection with the fertilizer studies in Pennsylvania acknowledgment is made of the helpful assistance of A. L. Hacker, County Agent of Lehigh County.

(Continued on page 24)

TABLE 3—EFFECT OF DIFFERENT PHOSPHATES ON YIELD OF POTATOES IN NEW JERSEY AND IN PENNSYLVANIA

	Average yield per acre					
	New Jersey[1]		Pennsylvania[2]			
	1937 Bu.	1939 Bu.	1938 Bu.	1939 Bu.	1940 Bu.	1941 Bu.
Ordinary superphosphate	240	203	440	190	255	341
Calcium metaphosphate	...	196	436	198	275	341
Calcined phosphate	...	200	...	186	...	...
Diacalcium phosphate	...	...	412	184	253	330
Fused phosphate	...	206	433	177	255	330
Monocalcium chlorophosphate (with KCl)	249	203	...	189	267	325
Monocalcium chlorophosphate (with K_2SO_4)	252	206	...	199	265	361
Potassium metaphosphate	246	208	...	188	258	362
Triple superphosphate	...	208	...	198	269	340
No phosphorus (4–0–8)	217	212	[3]	[3]	[3]	[3]
F value (5 per cent pt.)	...	...	non-sig.	sig.	non-sig.	sig.
Standard Error (per cent)	...	...	2.3	3.7	5.1	2.0
Bushels required for significance (5 per cent pt.)	...	...	...	20.0	...	18.0

[1] Soil type—Sassafras loam. 4–8–8 fertilizer mixture—1 ton per acre. 1937, average 12 replications; 1939, average 9 replications.
[2] Soil type—Berks shale loam. 4–8–8 fertilizer—1200 lbs. per acre. 1938, average 5 replications; 1939, average 6 replications; 1940, average 4 replications; 1941, average 2 replications.
[3] Not determined. In previous years phosphate applications on the same fields increased yields by 26 to 74 bushels per acre, or 8 to 18 per cent.

The American Chemical Society

Abstracts of some of the Papers presented at the Meeting of the Division of Fertilizer Chemistry at Buffalo, N. Y., September 7 to 11, 1942, H. B. Siems, presiding

(Abstracts of other papers were published in the September 12th issue.)

Fertilizer by Fusion of Rock Phosphate with Olivine

J. H. Walthall and G. L. Bridger, Tennessee Valley Authority, Wilson Dam, Ala.

It was found that by fusion of a mixture of rock phosphate, magnesia, and silica with subsequent rapid cooling of the melt, it is possible to make a product which has a high proportion of its P_2O_5 content soluble in citrated ammonium nitrate solution. Olivine, a mineral magnesium silicate found in abundance in the Tennessee Valley, is a suitable and economical source of magnesia and silica for the fusion process. For example, fusion of a mixture of one pound of rock phosphate and 0.46 pound of olivine yielded a product containing 22.8 per cent total P_2O_5 and 21.4 per cent soluble P_2O_5. One-fourth to one-third of the fluorine in the rock phosphate was volatilized in the process. Plant growth tests indicated that the product was practically as effective a source of P_2O_5 as superphosphate.

Because of the cheapness of the raw materials and the simplicity of the processing required, it is expected that the product can be made more cheaply, per unit of P_2O_5, than other phosphatic fertilizers. The magnesium content of the product should prove advantageous for many fertilizer applications.

Boron in Agriculture

E. M. Kitchen, Pacific Coast Borax Co., New York, N. Y.

The developments made in boron research in the United States and Canada during the past two years have covered some new crops. The findings, with respect to legumes, especially alfalfa, have been most interesting. Boron has shown remarkable results in increasing hay yields and has shown effects on seed set. The paper reviews the latest work on legumes.

New Horizons in Nitrogen

Arthur M. Smith, Synthetic Nitrogen Products Corp., New York, N. Y.

The first world consciousness of a nitrogen problem was that of shortage, culminating in predictions of the ultimate starvation of the human race at the end of a losing conservation economy. When commercial fixation of atmospheric nitrogen was established extensively, the picture changed to one of competition for the known existing markets. Sales pressure reduced prices and stimulated research for new uses, both industrial and agricultural. There was evidence that utilization might soon equal existing production capacities.

The present war, emphasizing national needs, has created new national production capacities in the United States and in many other countries. In the United States, and collectively throughout the world, these new production capacities vastly exceed all previously known peacetime requirements for nitrogen. Moreover, many of these factories, strategically and economically located with reference to raw materials, will establish new record low costs of production.

It is not too early for chemists and others, individually and through national organizations, to consider how these vastly increased supplies of fixed nitrogen may be used to advantage. In industry, along with the production of new synthetics, plastics and solvents, the wider use of ammonia as an industrial alkali, and of nitric acid in competition with other acids, should be considered.

In agriculture, research workers should examine the data from their nitrogen experiments to determine what quantities could be used profitably at new anticipated lower price levels. Vastly increased supplies of nitrogen materials delivered to the consuming areas at lower prices present an opportunity for increasing known uses and developing new uses through research. Among these new uses is the possibility of an increased nitrogen economy through the acidulation of phosphate rock with nitric acid.

The Bearing of Potassium on the Quality of Tobacco

D. E. Haley, The Pennsylvania State College, State College, Pa.

A study has been made of factors controlling yield, quality, and disease resistance in Pennsylvania cigar leaf and Virginia fluecured tobacco.

It has been found that practices which result in high yield do not necessarily result in the production of either good quality or disease-resistant tobacco. Likewise disease

resistance may be obtained by practices which are not in all cases productive of either satisfactory yield or quality. On the other hand, it has been found that excellence in quality is always accompanied by satisfactory resistance to leafspot diseases and is usually associated with satisfactory yield.

Excellence in quality has been found to be the result of growth without serious interruption and well balanced assimilation of nutrients.

Growth interruptions are usually the result of inequitable distribution of rainfall. The use of readily fermented green manures and well fermented animal manures affords protection against growth interruption. The use of old plant residues or raw animal manures may have the opposite effect if conditions for fermentation of this material in the soil are poor.

It has been found that to ensure quality and disease resistance, assimilation of the necessary minerals must bear a direct relation to nitrogen uptake. Of these minerals potassium is the most important with respect to amount required, and potassium deficiency has been found most often associated with lack of quality and susceptibility to disease. The quality plant assimilates at least as much and often somewhat more potash than nitrogen.

Plant Analysis as a Diagnostic Procedure

Albert Ulrich, Plant Nutrition Department, University of California, Berkeley, Calif.

One of the oldest procedures proposed by agricultural workers for ascertaining the fertilizer requirements of crops has been the analysis of the plants themselves. By establishing the "normal" nutrient content of the plant, it was hoped that any deviations from the "normal" could be corrected by the addition of the required fertilizer. Through numerous investigations it was established that many factors influenced the nutrient content of the plant and, therefore, the determination of the "normal" nutrient status of the plant was abandoned.

In the present review the cardinal disadvantage of plant analysis, as set forth by the opponents of the method, is considered one of its main assets. The analytical value obtained at a given moment reflects all the factors which have influenced the concentration of the nutrient in the plant. This relationship may be expressed in the following generalized equation:

(Concentration of a nutrient = f (soil, climate, plant, time, management,—)

Instead of referring the nutrient content of the plant to the "normal," it is referred to the critical limits previously established to be associated with a deficiency. These limits, which are relatively narrow and little influenced by the variables in the foregoing equation, must be determined for each crop and for each nutrient.

Not all parts of a given plant nor all forms of a given nutrient reflect the nutrient status of the plant with the same degree of sensitivity. The potassium status of grapevines is indicated better through an analysis of the petioles rather than the blades. Nitrates in the petioles are a better indicator of the nitrogen status than nitrates in the corresponding blades, and for that matter, are better than other forms of nitrogen (soluble, insoluble, or total) either in the petioles or blades. Phosphates soluble in 2 per cent acetic acid indicate the phosphorus status of the plant better than the total phosphorus content of a given plant part.

Present Status of Plant Hormones

P. W. Zimmerman, Boyce Thompson Institute for Plant Research, Inc., Yonkers, N. Y.

Phenoxy and benzoic acids substituted in the nucleus with halogen, methyl, and nitro groups have opened a new line of attack on plant hormone problems. Phenoxyacetic acid is slightly active for cell elongation but does not induce formative effects of growing plants. When substituted in the ortho and para positions, the resulting dichlorophenoxyacetic acid is very effective, causing cell elongation, adventitious roots, parthenocarpy, and various formative effects. Parachlorophenoxyacetic is less active than the dichloro, and the ortho compound is less active than the para. Bromo-substituted compounds are slightly less active than the chloro. 2, 4, 6-Tribromophenoxyacetic acid is inactive, but 2, 3, 5-triiodobenzoic acid is very active. The higher homologs, such as chlorophenoxy-alpha-propionic acid and chlorophenoxy-alpha-butyric acid are active for cell elongation and adventitious roots but not very active for formative effects. Benzoic acid is physiologically active until substituted with halogen or nitro groups. 2–Chloro-5-nitrobenzoic acid is inactive for cell elongation but is active for modifying the pattern of leaves. 2-Bromo-3-nitrobenzoic acid is active for both factors. Considering the increased activity of substituted phenoxy and benzoic acids over phenoxy and benzoic acids, it appears that the activity of many other substances in the hormone field might be increased by this method.

The principal practical uses for growth substances to date are to propagate plants from cuttings, prevent preharvest drop of apples, induce seedless fruit (especially tomatoes), and inhibit buds (especially buds of potato tubers). Flowering of plants can be regulated to some extent with several of the most active compounds. Treatment of seeds with growth substances to increase the crop has not been effective.

Movement of Fertilizer in Soil from Band and Broadcast Applications

M. S. Anderson, Colin W. Whittaker, and Paul R. Henson, Soil and Fertilizer Investigations, Bureau of Plant Industry, U. S. Department of Agriculture

Field plot fertilization experiments were conducted on two soil types. On each soil type Sudan grass was grown on one set of plots and another set was kept fallow. The two soil types show markedly differing rates at which soluble constituents of added fertilizer disappear from their place of application.

The course of soluble material through a part of the soil profile is indicated by electrical conductivity measurements made on soil taken at the time of harvesting the first crop of Sudan grass and again the following spring. The extent and nature of base-exchange reactions taking place are indicated by variations in several water-soluble constituents of soil containing a fertilizer band and in soil taken in a thin layer at the soil surface. Soil samples containing a band of 6–8–4 fertilizer that has been undisturbed in a field for nearly a year, show a marked residue of water-soluble phosphorus. Similar acre applications made broadcast on a silt loam soil are almost completely "fixed" into water-insoluble form. However, on a very sandy soil, some phosphorus remains water-soluble from broadcast applications.

American Potash Reserves

George R. Mansfield, Geological Survey

World War II finds the United States equipped with a potash industry well established with adequate supplies of raw materials, methods of production carefully worked out, plant capacities ample for expected demands, and prices little affected by the disturbed conditions of world trade. Reserves may be grouped in three classes: (1) Soluble-potash salts and brines now in active production: the sylvite and langbeinite beds mined in New Mexico and the brines of Searles Lake, Calif., and of the Salduro area in the Great Salt Lake Desert, Utah. At the present annual rate of approximately 500,000 tons of K_2O these sources as now known could probably supply the country's needs for about 200 years. (2) Carnallite and alunite beds in Utah under investigation for operation with magnesium or aluminum as the principal product but with potash as a co-product. These reserves, especially the carnallite, cannot be estimated from present data but may be large; their technology is already well understood. (3) Mineral supplies abundant enough for large-scale production but subject to technological advances, development of marketable co-products, and other limiting factors. These include polyhalite, leucite, greensand, and others. The available quantities are enormous and it is not unreasonable to think that by the time supplies of the first two classes of material are exhausted conditions may be ripe for exploitation of those of the third class. In any event, the potash industry in America in the next few years is more likely to be affected by international and domestic political and social conditions arising from the war than by any lack of suitable raw materials.

Potassium Fixation by Corn-Belt Soils

E. E. Deturk, R. H. Bray, and L. K. Wood, University of Illinois

Fixation of added soluble K by some Illinois soils was brought about by moist storage in closed containers for 3 years. Earlier studies had shown, however, that equilibrium is attained in 16 to 25 weeks. The K removed by exhaustive 0.5 *N* acetic acid leach at the end of the 3 years was deducted from the sum of the initial replaceable K and the K added to obtain fixed K. This value is only approximately correct because of shifts in the equilibrium in untreated check soils during moist storage.

Addition of 200 parts soluble K or more per million parts of dry soil resulted generally in fixation by Illinois surface soils, as fixation is above defined. K so fixed is probably identical in status with part of the K already present in field sorts. Soils varying widely in properties varied only moderately in the amounts of K fixed from uniform additions. A low-exchange capacity planosol, highly K-deficient and low in organic matter, fixed 200 p.p.m. of K from 500 p.p.m. addition, as compared to 203 p.p.m. fixed in a youthful, productive nondeficient soil high in organic matter. The maximum fixed from 500 p.p.m. was 335 p.p.m.

In a given soil the amount fixed increases with the amount added, but not in the same proportion (Table I). No maximum fixation capacity was found. Part of the fixed K was

(Continued on page 20)

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The N. F. A. in the National Emergency

IN ITS Annual Report to the members of The National Fertilizer Association, that organization lists an imposing number of services which are being rendered not only to its membership but to every manufacturer of fertilizer and fertilizer materials. Such items as the motion pictures, "Green Acres," "Putting Plantfood to Work" and the new film, "The Life of the Soil," which have been shown to over a half-million farmers, and the other branches of Soil Improvement work, including pamphlets, field experiments, sectional meetings, etc., have a real dollars-and-cents value to every firm in the industry. Other important departments are dealing with cooperative research on methods of fertilizer application, symptoms of malnutrition in the principal crops, methods of using new forms of fertilizer materials, etc.

Among the other features of the Association's activities should be mentioned the quarterly publication of *The Fertilizer Review*, the weekly *N. F. A. News*, the weekly *Price Index*, the monthly reports on *Tag Sales* and on *Superphosphate Production*. Developments of the past year have emphasized the importance of having reliable statistics readily available. With some fertilizer materials unobtainable, it is vital to know the quantities of the others that can be used for fertilizer purposes.

With the attack on Pearl Harbor the National Fertilizer Association signed up "for the duration." Many times a day the Washington office is called upon for information by one or more of the governmental war agencies. Nine Regional War Emergency Conferences were arranged for the spring of 1942, by means of which the industry had the opportunity to discuss their problems with government officials and to arrange for the appointment of an industry committee to act with the Government on defense problems.

While the influence of the Association has been relatively great because the membership represented a large proportion of the fertilizer tonnage of the country, the organization will not be 100 per cent effective until every fertilizer manufacturer is enrolled as a member. During the past few months, over 50 firms have been added to the active membership list. It is hoped that the Association's immediate goal of 100 new members will be soon reached, after which a campaign for 100 per cent industry enrollment can be undertaken.

September Crop Report

The September crop report estimates United States corn production at 33.7 bushels per acre, or a total of 3,016,000,000 bushels, just slightly under the record crop of 1920; wheat production at 19.4 bushels per acre, which, with oats, will be the largest crops since 1915. Barley, grain sorghums, and rice are near record crops, which will make a total of 5 per cent more grain than the record year of 1920. With 6,252,000 tons of cottonseed, 211,000,000 bushels of soybeans, 42,500,000 bushels of flaxseed, and 1,465,000 tons of peanuts, oil seeds may total 44 per cent more than any past year. Sugar beet and sugar cane crops are also largest in history. Record yields per acre are forecast for corn, wheat, rye, cotton, hay, beans, peas, potatoes, with near record crops of pasture, tobacco, and many vegetables and fruits. Better fertilizing practice is given as one reason for these high yields.

Florida Tax on AAA Fertilizer Opposed

The U. S. Department of Justice has instituted court proceedings to test the right of a State to levy a fee on fertilizers distributed to farmers by AAA. In a number of States the usual fertilizer inspection tax has been waived on fertilizers under the AAA program. In Florida, however, the State officials have insisted upon collecting the tax of 25 cents per ton on all fertilizer, no matter what its destination. The U. S. government has obtained a temporary restraining order to prevent the seizure of AAA fertilizers by Florida officials and on September 29th a further hearing will be held. Florida officials have indicated that they will make an issue of the question and contest the case in the courts.

Smith-Rowland Plant Burns

The plant of the Smith-Rowland Company, in Norfolk, Va., one of the largest enterprises engaged in the production of nitrogenous fertilizer material in the United States, was destroyed by fire September 1st. Besides the Norfolk plant, the Smith-Rowland Company also owns and operates a nitrogenous material factory in Chemical, Ill. The burned plant is to be rebuilt.

I. M. C. Reports Increased Earnings

In the annual report to the stockholders of the International Minerals and Chemical Corporation, President Louis Ware reported that net profits after all charges amounted to $1,786,342.10 for the fiscal year ended June 30, 1942. Earnings on the common stock outstanding, after provision for a full year's dividends on the preferred shares, amounted to $2.97 per share. Net current assets totaled $7,188,385.90 as compared with $6,601,341.08 on June 30, 1941.

The figures for the current year are for the company following the merger with its subsidiary, Union Potash and Chemical Company, which was effected on March 31, 1942.

No profits from war business were realized during the year, except a relatively small engineering fee earned on government construction work. It has not been necessary for the Corporation to make changes in the plants on account of the war. The mines and factories have continued as normal but operating at capacity because of present demand for its goods. From its potash, phosphate mines, and fertilizer plants, the Corporation has supplied vitally needed materials that aid the nation's record crop-producing and chemical needs for the war effort.

In addition the Corporation has assumed the responsibility for the construction and operation of two large war plants for the account of the government.

Fertilizer sales increased 3.5 per cent over last year, whereas fertilizer consumption over the entire United States was reported to be up 3 per cent. The demand for fertilizer was greater than the supply and all of I. M. C. plants produced at capacity and were completely sold out of all finished goods at the end of the season. While there was continued rise of cost of raw materials and labor, the results of the Fertilizer Division during the year were on the whole satisfactory.

The Chicago Heights plant was destroyed by fire on December 15, 1941, but was totally covered by insurance and was rebuilt in time to meet its production requirements for the current season.

The new Peace Valley Phosphate Mine in Florida was completed and began production during the last month of this fiscal year. This plant takes the place of other smaller plants that had become exhausted and, by concentrating the productive capacity in one large plant, it is expected increased efficiencies will be realized which will be re-

flected in the coming years' business. Peace Valley is located in a new mining area of unusually high-grade phosphate. With this new plant, International is in position to realize on any increased demand from the Florida fields for domestic or export needs.

In Tennessee the Corporation acquired by purchase additional important reserves of phosphate rock at favorable prices, which makes more secure its future in that field. Further improvements at the mines and plants, together with increased shipments, accounted for satisfactory results from Tennesee operations.

Since the merger of Union Potash and Chemical Company with the parent organization, effective March 31, 1942, the potash business has been conducted as the Potash Division of International. During the year there were produced 213,625 tons of the various potash salts, which were shipped to consumers over the United States, a small amount being exported to Canada, Puerto Rico, Cuba and Hawaii. This is the first full year's production of the new plant and its performance and quality of the material produced were satisfactory. The demand for potash is such that the continued operation of the plant at capacity during the coming year is assured. During the year approximately a half million dollars of added capital was spent at the potash mine and refinery to further increase its capacity and improve its operation. It is estimated that a like amount will be expended in the coming year for further needed improvements and additions.

In addition to its fertilizer business, the company is engaged in the supervision and management of two government-owned magnesium plants. A new plant for the production of potassium chlorate is under construction at Cincinnati.

Potash Advisory Group Formed

A Potash Producers Industry Advisory Committee has been formed, according to an announcement by the Division of the Industry Advisory Committees of the War Production Board. T. E. Milliman of the Chemicals Branch is the government presiding officer and the other members of the Committee are: Horace M. Albright, United States Potash Company; Cecil B. Baker, American Potash and Chemical Corporation; J. B. Grant, Potash Company of America; James P. Margeson, Jr., International Minerals and Chemical Corporation.

Petitt Elected P. C. A. Director

George E. Petitt, vice-president in charge of sales of Potash Company of America, has been elected a member of that company's board of directors. Before joining the executive staff of the Potash Company, Mr. Petitt was senior vice-president of the Chilean Nitrate Sales Corporation. Previous to that affiliation, he had been associated with other fertilizer and agricultural raw material producers.

Amendments to Order M-231

Order M–231 of the War Production Board, regulating the sale of mixed fertilizers, has been amended by a supplementary order on September 23rd. Sales of fertilizers containing chemical nitrogen are permitted to the Army, Navy or Coast Guard for use on new plantings of grass on airports and airfields. The list of approved grades for Arkansas was corrected by changing the 0–20–20 grade to 0–10–20.

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FERTILIZER MATERIALS MARKET

NEW YORK

Shortage of Chemical Nitrogen Causes Increased Demand for Organic Materials but High Materials Prices Conflict with Ceiling on Mixed Fertilizers. Potash and Superphosphate Supplies Adequate at present

Exclusive Correspondence to "The American Fertilizer"

NEW YORK, September 22, 1942.

With the curtailment of inorganic ammonia of all kinds for use by the fertilizer manufacturers, naturally, these manufacturers are looking more and more for organic ammoniates to replace the various inorganic ammoniates which they have been using.

However, as pointed out before, the costs of the various meals is such that, with ceilings for complete fertilizers, the fertilizer manufacturers cannot afford to use any large quantities of these meals.

Probably complete fertilizers will be used for the coming season with little or no ammonia content, the farmers in different parts of the country using farm manure as much as possible to help to correct this lack in the mixed fertilizer. In subsequent years it is possible that the consumers of fertilizer will attempt to plow under a certain portion of their crops to add the nitrogenous content to the soil.

The situation in nitrogenous has been further aggravated by the destruction by fire of one of the larger nitrogenous plants.

Sulphate of Ammonia

There is nothing new to report in this community.

Potash

Also nothing new to report on this article, manufacturers being completely sold up. Deliveries are being made regularly against contract obligations and will continue unless the demands for delivery for export are larger than anticipated, which demands would only be taken care of, probably, on direct instructions from Washington.

Superphosphate

This material continues in good demand and the supply will probably be ample but if large quantities of triple superphosphate are required for export under the Lend Lease program, the situation in superphosphate will undoubtedly tighten up considerably.

BALTIMORE

Demand for Organics Continues. Nitrogenous Prices Withdrawn. Fishing Season May Show Late Improvement

Exclusive Correspondence to "The American Fertilizer"

BALTIMORE, September 22, 1942.

There have been no outstanding features in connection with the fertilizer business during the past two weeks.

Organic Ammoniates.—The demand for tankage and blood for feeding purposes continues good, with further sales reported at ceiling prices of $6.00 per unit of nitrogen, f. o. b. shipping points, which figure, of course, takes these products out of the class of fertilizer material.

Nitrogenous Material.—Due to destruction by fire of one of the largest plants and scarcity of raw material, all manufacturers have withdrawn quotation for the time being. Ceiling prices fixed on vegetable meals containing nitrogen are almost too high to be of use extensively in mixed goods at prevailing prices.

Sulphate of Ammonia.—There is no change in the situation. Output is still being allocated under reduced basis as compared with the tonnage taken last year.

Nitrate of Soda.—There is not likely to be any important change in the market and deliveries likewise are being allocated to manufacturers based on last year's deliveries.

Fish Scrap.—There is no new business passing and in some quarters it is now felt that if favorable weather continues over the

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balance of the season, producers will be able to complete current contracts.

Superphosphate.—The market is unchanged at ceiling price of $9.60 per ton of 2,000 lbs., basis 16 per cent, for run-of-pile, in bulk, f. o. b. producers' works Baltimore. The Government has issued regulations prohibiting the use of superphosphate containing less than 18 per cent A. P. A. as a conservation measure.

Bone Meal.—Due to Government restriction prohibiting the use of mineral nitrogen on lawns, golf courses, etc., it is anticipated there will be a good demand for bone meal, which, however, is in short supply.

Potash.—Domestic producers are practically sold up for the coming season, and no new activity is reported.

Bags.—No change in the burlap situation which is still acute, but prices may ease off somewhat in the spring at which time shipments covered by Government war risk insurance on a much lower basis will be available. However, burlap bags will still be very much higher than the prevailing market on paper bags, so that very few of the fertilizer manufacturers figure on using burlap next spring except in isolated cases.

CHARLESTON

Quotations on Some Organics Impossible to Obtain. Authorized Fertilizer Grades Announced

Exclusive Correspondence to "The American Fertilizer"

CHARLESTON, September 21, 1942.

Soy meal producers are still withholding quotations for future shipment, pending agreement with the Commodity Credit Corporation. The following number of fertilizer grades have just been authorized by the War Production Board: for South Carolina, 13; for Georgia, 13; for North Carolina, 18; and for Florida, 33.

Nitrogenous.—It is still impossible to obtain any quotations on this material.

Castor Meal.—Quotations are not being made on this material.

Blood.—The price still takes this material completely out of range as far as the fertilizer manufacturers are concerned, and even the feed manufacturers are unable to obtain sufficient supplies. Last market prices are $5.85 per unit of ammonia ($7.11 per unit N), f. o. b. Chicago.

Cottonseed Meal.—Prices on the 8 per cent grade are as follows: Atlanta, $36.00; Memphis, $35.25.

TENNESSEE PHOSPHATE

Corn and Tobacco Crops at Top Levels. Phosphate Rock Shipments to Pass Previous Records

Exclusive Correspondence to "The American Fertilizer"

COLUMBIA, TENN., September 21, 1942.

Corn is rapidly ripening in the fields, with the last sign of green about gone, and all predict the biggest corn crop for years. Tobacco is about all out and in the barn, many are stripping and prospects on all sides point to the biggest and best crop of that better and milder leaf for which the cigarette manufacturers pay the highest price.

Movement of phosphate rock into all consuming channels is at the top speed of the season and all doubt is gone as to 1942 showing up at the end with the largest tonnage ever shipped out of and consumed in Tennessee during the 49 years since Tennessee phosphate rock deposits were discovered as a commercial possibility on Swan Creek.

All farmers working under the AAA program in states where AAA allows benefit payments for the application of phosphate rock are trying hard to get it applied before the October 1st deadline and, of course, many

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who waited till the last month are doomed to disappointment. It is conservatively estimated that over $50,000.00 in benefit payments will be lost by Illinois farmers alone who have been unable to get shipments in time.

It is indeed cause for wonder to note the difference between the attitudes of the AAA in different states on this subject, and one wonders if grown men can really be so ignorant as either side must be if the other side is anywhere near right.

Stocks of both raw material mined and ready for preparation and of washed material ready for drying are rapidly diminishing, while finished product in stock is non-existent.

CHICAGO

Little Change in Well-Sold-Up Fertilizer Organics Market. Feed Materials in Demand but Supply Scarce

Exclusive Correspondence to "The American Fertilizer"

CHICAGO, September 21, 1942.

No changes or new developments have occurred in the organic market, and it continues as a quiet and firm situation. Sellers are reporting a well-sold-up position and therefore offerings are restricted. Bids for blood for feed are $5.85 ($7.11 per unit N), basis Chicago, but offerings are lacking.

In the feed market demand continues for dry and wet rendered tankage at ceiling prices, but offerings are narrow; thus such trading which does occur is on a small scale.

Nominal prices remain at the ceiling as follows: High grade ground fertilizer tankage, $3.85 to $4.00 ($4.68 to $4.86 per unit N), and 10 cents; standard grades crushed feeding tankage, $5.37 per unit ammonia ($6.53 per unit N); blood, $5.85 to $5.90 ($7.11 to $7.17 per unit N); dry rendered tankage, $1.21 per unit of protein, Chicago basis.

A Rationing System for Farm Machinery

On September 17th, Secretary of Agriculture Claude R. Wickard announced a temporary order prohibiting the sale of new farm machinery and equipment, except as specified in a rationing system governing its release. The temporary order takes effect September 17, 1942, and will be followed later by a permanent order governing the release of farm machinery in 1943.

The order outlines conditions under which farm machinery and equipment may be purchased, and sets up procedure and organization for rationing the available supply among farmers.

Authority to ration farm machinery and equipment was delegated to the Department of Agriculture by the Office of Price Administration in an order effective September 16th. Previous to that, the War Production Board issued a directive authorizing OPA to ration farm machinery or redelegate the authority.

In general, the farmer will be required to show that his present equipment is not adequate to handle his production, that he cannot meet his equipment needs by repairing existing equipment, by purchasing or renting used equipment, by custom work or other means. He must also show that failure to

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approve his application will result in a substantial reduction in production of commodities essential in the war effort, and that the machinery will give better than average service for similar equipment in the community.

Items in a second group (Group B), include most other farm machinery and equipment not in the first group, and which may be sold upon certification by the farmer to his dealer that the equipment is essential for current agricultural production needs.

Items in the third group include such items as some hand tools and the smaller horse-drawn equipment, which may be sold without restriction.

The temporary rationing plan does not apply to repair parts, and excludes such items as automobiles, trucks, tracklaying tractors, or equipment ordered by Governmental agencies.

Instructions for issuing applications for purchase certificates and other procedure have been sent to State and County USDA War Boards.

In cases where an applicant is denied a purchase certificate by the county rationing committee, provision is made for an appeal to the County Rationing Committee and from there to the State USDA War Board, and to the Secretary of Agriculture through the special War Board Assistant.

Farm Income Increasing

The U. S. Department of Agriculture now estimates the cash farm income from marketings of farm products will approximate 15 billion dollars in 1942. Three months ago, the estimate was about 14 billion dollars.

THE AMERICAN CHEMICAL SOCIETY

(Continued on page 11)

extracted by boiling 10 minutes with excess 1.0 *N* HNO_3 but not all of it was extractable by this treatment.

After 3 years' moist contact with soluble K salts, samples were exhaustively leached with 0.5 *N* acetic acid followed by 60 per cent methyl alcohol wash. Each soil was then stored moist and similarly leached five successive times after intervals of 30, 30, 90, 90, and 90 days in order to determine rate of release with disturbance of the equilibrium. The cumulative release of fixed K to the replaceable form for four soils during the entire period of 330 days was 225, 151, 117, and 126 p.p.m., these amounts being 118, 45, 45, and 63 per cent respectively, of the K fixed from a 500 p.p.m. addition. The 118 per cent release (excess 18 per cent from native soil K) occurred in the non-deficient soil. The 63 per cent release occurred in the highly deficient planosol.

In a given soil the amount of K released increases slightly with increasing amounts fixed, but the percentage released decreases greatly (Table I).

Table 1

K Fixation and Release in a Planosol
(Cisne silt loam)

K added p.p.m.	K fixed p.p.m.	K released within 30 days p.p.m.	K released within 330 days p.p.m.	K released within 330 days % of fixed K
0	19	0	52	(274)
200	113	19	84	74
500	200	44	126	63
1000	370	73	147	40
2000	810	80	166	20
9775	3560	138	258	7

These results indicate (1) that K fixation has the characteristics of an equilibrium adsorption reaction, its slowness suggesting adsorption in the interior recesses of the colloidal particles, and (2) that K fixed by the soils used would be released under field conditions following crop or other removal, to a significant extent and at a sufficiently rapid rate to give it practical value in crop production.

Calcium and Potassium Interrelationships in Alfalfa

Firman E. Bear, Stephen J. Toth, and Albert S. Hunter,
New Jersey State Agricultural Experiment Station

A study of (1) the effect of widely varying Ca/K rations in the exchange complex of a Dutchess loam soil upon the growth and composition of Hardistan alfalfa, and (2)

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the absorption by alfalfa of exchangeable and nonexchangeable nutrients from this soil. Alfalfa was grown through seven crops over a period of 13½ months, in mixtures of washed sand and synthetic Dutchess loam soil, having a nearly constant pH, known, constant, and ample quantities of S, trace elements (Cu, Zn, Mn, B, Fe), adsorbed P and exchangeable Mg, and with exchangeable Ca/K ratios of 1/1, 2/1, 4/1, 8/1, 16/1 and 32/1. A maximum cumulative yield equivalent to 46 tons of dry matter per two million pounds of soil was obtained. Each alfalfa crop, and the roots, were analyzed for ash, Ca, K, Mg, P, S, and N. The exchangeable nutrients and base-exchange capacity of the soil were determined at the beginning and end of the experiment. It is concluded that (1) within limits, the absolute amounts of nutrients present in the soil in the exchangeable form are of more significance than the ratios between them, and (2) alfalfa can absorb considerable quantities of nonexchangeable K from the soil minerals.

Tissue Testing (Quick Test) in Diagnosis

George D. Scarseth, Purdue University Agricultural Experiment Station, Lafayette, Ind.

Many fertilizer experiments have failed to give true information because of the assumption that the growing crop was adequately supplied with a nutrient simply because the nutrient had been added to the soil as a fertilizer in adequate amounts. It is of greatest importance to know if the nutrient is being absorbed into the plant or not, for improper placement, dry soil, or fixation might have prevented the uptake of the nutrient.

Frequently, experiments have been conducted to determine the crop response to a particular nutrient element with the results that no increases in yields were obtained even though it was reasonable to believe that the soil was deficient in this element. In such experiments the effects of other elements have presumably been eliminated by their additions as constants. Since no response was obtained from the element studied, the conclusion has unfortunately often been drawn that the element was not needed. It is in such instances that any information on the nutritional status inside of the growing plant becomes most helpful.

The Purdue plant tissue test method presents a semi-qualitative technique that permits such observations to be made of the plants during the growing period. The method measures only the unsynthesized nitrates, phosphates, and potash in the conducting tissues of the plants. In this respect the supply status of these nutrient elements can be determined. Testing the different parts of the plant tissues and at various stages of growth adds to the information that can be obtained and used in diagnosing the nutritional status of the plant fertility of the soil.

Practical Aspects of Potassium Interrelationships

L. D. Baver, North Carolina Experiment Station, Raleigh, N. C.

The practical use of potash in the production of crops is usually based upon: (1) the potassium requirement of the specific crop as related both to growth and quality; (2) the amount of potash supplied by the soil; and (3) the system of farming or the fertilization of the rotation.

There are distinct differences in the potash requirements of various crops. For example, legumes are heavy feeders of potash. Most grasses, however, can produce good growth with less amounts of available potash present. The quality of the crop may be illustrated in the effect of potash on the size and shape of the sweet potato and the effect of potassium on the quality of flue-cured tobacco. Hence, the type of crop to be fertilized is extremely important in making practical application of potassium-plant interrelationships.

The amount of available potassium in the soil varies considerably with the soil type and the management of the soil. These variations were discussed in other papers. However, it is obvious that potash fertilization will vary with soil types.

The use of potash in the system of farming has many important ramifications. For example, legumes in the rotation may have several effects on the potash fertilization of the succeeding crops. In the first place, it

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has been shown that the turning under of large quantities of legumes may cause a disturbance of the potassium-nitrogen relationships that will result in decreased yields of corn or other crops. This excess nitrogen can be balanced by heavy potash fertilization. In the second place, the cutting of legumes for hay which results in a complete removal of the crop, often accentuates the potash needs of the succeeding crops. Thus, the ratio of potash to nitrogen and phosphoric acid must be controlled to satisfy the condition in question.

Another important factor in the use of potash in the rotation is the calcium-potassium relationships. In general, on soils that have low potassium reserves, liming increases the need for potash. This is particularly true when legumes are being grown. In the light sandy soils of the south, it has been shown that applications of lime decrease the rate of leaching of potash. Also, particularly in the south, the effect of potash on legume crops, such as peanuts, is determined primarily by the calcium and magnesium present. These are examples to point out that the use of potash in a rotation necessitates many important considerations.

The time, rate, and method of application of potash are associated with the ready solubility and rather rapid mobility of potash in the soil. This involves salt effects on young plants, side placement, and top-dressings.

NUTRIENT VALUE OF SOME NEW PHOSPHATE MATERIALS USED ON POTATOES

(Continued from page 8)

pared were formulated in 4–8–8 fertilizer mixtures and these were applied in bands at the side of the seed-piece at the rate of 1,200 pounds per acre. At times it was necessary to omit some treatments owing to scarcity of certain of the phosphatic materials. The Russet Rural variety was grown from certified seed each year of the experiment. The results obtained are given in Table 3.

The results in Pennsylvania show clearly the effects of dry weather in 1939 and 1940. Although the farm on which these experiments were located is capable of producing heavily, the yield of potatoes depends more than ordinarily on the amount and distribution of rainfall. This is due to the occurrence of underlying sandstone ledges which are unusually close to the surface soil. It will be noted from Table 3, however, that the results for the dry years 1939 and 1940 showed no indication of injurious effect from any of the new phosphatic materials during these years. In these experiments fused phosphate produced the lowest yield (177 bu. in 1939), but in comparison with ordinary superphosphate for the same year the reduction in yield was not significant. In 1941 monocalcium chlorophosphate with sulphate of potash and potassium metaphosphate each produced significant increases over ordinary superphosphate. It is also interesting to note that the yields from the chlorophosphate mixture with sulphate of potash exceeded those from the same mixture with muriate 2 out of 3 years, and in 1941 the difference was significant. In general, the results for Pennsylvania indicate favorable responses from the new phosphatic materials as used in the potato fertilizer.

Discussion

The fineness to which many phosphatic materials are ground undoubtedly has a distinct bearing on their nutrient value as measured in crop response; however, this does not mean that grinding to extreme fineness will necessarily increase the efficiency of all phosphatic materials. In this regard Jacob and Ross (*5*) point out that from the results of greenhouse tests they have found that little is gained in the efficiency of calcined phosphate by increasing its fineness beyond 80 mesh. Other phosphatic materials studied by the same authors were ground to pass either 80 or 100 mesh.

The materials used in the present study were not uniformly ground to pass 80 mesh but in appearance they could all be classed as "finely ground," and with the exception of the superphosphates had a much finer appearance than commercial potato fertilizers. This condition probably was due in some instances to the density of the material as well as fineness of the particles. However, no difficulty in distribution was experienced in the field as long as precautions were taken

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See Page 4

to prevent channeling of the denser mixtures in the fertilizer hopper.

In considering the responses obtained with the different phosphatic materials it is important to remember that soils used for potatoes are usually acid in reaction in order to avoid scab infection. The soil reaction in all the present experiments was distinctly acid; in Maine pH 5.2, in New Jersey pH 5.2, and in Pennsylvania pH 5.6.[6] These soil reactions undoubtedly contributed to the favorable nutrient response of the phosphatic materials studied. Under alkaline soil conditions, however, some of the newer phosphatic materials have not given satisfactory results. Toevs and Baker (*6*) definitely advise against the use of fused phosphate on the high-lime soils of Idaho. Jacob and Ross (*5*) also reported results of greenhouse experiments in which calcined phosphate, fused rock phosphate, calcium metaphosphate, and other types of water-insoluble phosphates were less effective than water-soluble monocalcium phosphate or superphosphate under alkaline soil conditions. Gilligan (*7*) in a recent publication concludes that from availability data alone it would appear that metaphosphates would be less efficient than superphosphate, but he points out that the low water-solubility of the metaphosphates may not be retained when added to soil and calls attention to the importance of properly controlled field experiments in making an ultimate test of their value to crops. From the results of the present experiments it would seem that the supply of available phosphoric acid provided by the water-insoluble phosphates during the growing season was adequate for the production of satisfactory yields of potatoes on these acid soils. With soil reactions of pH 5.0 to 5.5 there seems little likelihood of reduced efficiency of the water-insoluble phosphates tested, as a result of too high alkalinity when they are used on potato soils in the east.

Summary

Potato fertilizers each with phosphoric acid supplied by one of eight phosphatic materials, including ordinary and triple superphosphate, calcined phosphate, fused phosphate, dicalcium phosphate, calcium metaphosphate, monocalcium chlorophosphate and potassium metaphosphate, were compared in Maine, New Jersey, and Pennsylvania over periods of 2 to 4 years. Results of these experiments indicate that none of the materials as used was injurious to potatoes. Yields were not always equal to those with ordinary superphosphate but the responses were regarded as satisfactory considering the types of materials represented. The potato crop, grown on acid soils, was apparently able to utilize phosphorus readily from these new phosphatic materials.

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(*7*) Gilligan, G. M., "The Penetration and Availability of Metaphosphates in Soils," University of Delaware Agricultural Experiment Station Bul. 229 (April, 1941).

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[6] This reaction is not typical for Berks Shale loam which is usually around pH 6.4.

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HOISTS—Electric, Floor and Cage Operated, Portable
Hayward Company, The, New York City.

HOPPERS
Atlanta Utility Works, East Point, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

IMPORTERS, EXPORTERS
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Wellmann, William E., Baltimore, Md.

IRON SULPHATE
Tennessee Corporation, Atlanta, Ga.

INSECTICIDES
American Agricultural Chemical Co., New York City.

LACING—Belt
Sackett & Sons Co., The A. J., Baltimore, Md.

LIMESTONE
American Agricultural Chemical Co., New York City.
American Limestone Co., Knoxville, Tenn.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
McIver & Son, Alex. M., Charleston, S. C.
Wellmann, William E., Baltimore, Md.

LOADERS—Car and Wagon, for Fertilizers
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

MACHINERY—Acid Making
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.
Duriron Co., Inc., The, Dayton, Ohio.
Fairlie, Andrew M., Atlanta, Ga.
Monarch Mfg. Works, Inc., Philadelphia, Pa.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MACHINERY—Coal and Ash Handling
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

MACHINERY—Elevating and Conveying
Atlanta Utility Works, East Point, Ga.
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MACHINERY—Grinding and Pulverizing
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

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MAGNETS
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Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MANGANESE SULPHATE
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Tennessee Corporation, Atlanta, Ga.

MIXERS
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Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

NITRATE OF SODA
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Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Barrett Division, The, Allied Chemical & Dye Corp., New York City.
Bradley & Baker, New York City.
Chilean Nitrate Sales Corp., New York City.
Huber & Company, New York City.
International Minerals & Chemical Corporation, Chicago, Ill.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

NITRATE OVENS AND APPARATUS
Chemical Construction Corp., New York City.

NITROGEN SOLUTIONS
Barrett Division, The, Allied Chemical & Dye Corp., New York City.

NITROGENOUS ORGANIC MATERIAL
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
DuPont de Nemours & Co., Wilmington, Del.
Huber & Company, New York City.
International Minerals & Chemical Corporation, Chicago, Ill.
McIver & Son, Alex. M., Charleston, S. C.
Smith-Rowland Co., Norfolk, Va.
Wellmann, William E., Baltimore, Md.

NOZZLES—Spray
Monarch Mfg. Works, Philadelphia, Pa.

PACKING—For Acid Towers
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.

PANS AND POTS
Stedman's Foundry and Mach. Works, Aurora, Ind.

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American Cyanamid Co., New York City.
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Schmaltz, Jos. H., Chicago, Ill.
Southern Phosphate Corp., Baltimore, Md.
Virginia–Carolina Chemical Corp. (Mining Dept.), Richmond, Va.
Wellmann, William E., Baltimore, Md.

PIPE—Acid Resisting
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PIPES—Chemical Stoneware
Chemical Construction Corp., New York City.

PIPES—Wooden
Stedman's Foundry and Mach. Works, Aurora, Ind.

PLANT CONSTRUCTION—Fertilizer and Acid
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

POTASH SALTS—Dealers and Brokers
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
International Minerals & Chemical Corporation, Chicago, Ill.
Jett, Joseph C., Norfolk, Va.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

POTASH SALTS—Manufacturers
American Potash and Chem. Corp., New York City.
Potash Co. of America, New York City.
International Minerals & Chemical Corp., Chicago, Ill.
United States Potash Co., New York City.

PULLEYS AND HANGERS
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

PUMPS—Acid-Resisting
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Duriron Co., Inc., The, Dayton, Ohio.
Monarch Mfg. Works, Inc., Philadelphia, Pa.

PYRITES—Brokers
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., New York City.
Wellmann, William E., Baltimore, Md.

QUARTZ
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.

RINGS—Sulphuric Acid Tower
Chemical Construction Corp., New York City.

ROUGH AMMONIATES
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McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
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Sackett & Sons Co., The A. J., Baltimore, Md.

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Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
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SHOVELS—Power
Link-Belt Company, Philadelphia, Chicago.
Link-Belt Speeder Corporation, Chicago, Ill., and Cedar Rapids, Iowa.
Sackett & Sons Co., The A. J., Baltimore, Md.

SPRAYS—Acid Chambers
Monarch Mfg. Works, Inc., Philadelphia, Pa.

SPROCKET WHEELS (See Chains and Sprockets)

STACKS
Sackett & Sons Co., The A. J., Baltimore, Md.

SULPHATE OF AMMONIA
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
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Wellmann, William E., Baltimore, Md.

SULPHUR
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Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M. ,Charleston, S. C.

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Ashcraft-Wilkinson Co., Atlanta, Ga.
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Bradley & Baker, New York City.
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International Minerals & Chemical Corporation, Chicago, Ill.
Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M., Charleston, S. C.
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SUPERPHOSPHATE—Concentrated
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International Minerals & Chemical Corporation, Chicago, Ill.
Phosphate Mining Co., The, New York City.
U. S. Phosphoric Products Division, Tennessee Corp., Tampa, Fla.

SYPHONS—For Acid
Monarch Mfg. Works, Inc., Philadelphia, Pa.

TALLOW AND GREASE
American Agricultural Chemical Co., New York City.

TANKAGE
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
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Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
Smith-Rowland, Norfolk, Va.
Wellmann, William E., Baltimore, Md.

TANKAGE—Garbage
Huber & Company, New York City.

TANKS
Sackett & Sons, Co., The A. J., Baltimore, Md.

TILE—Acid-Proof
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.

TOWERS—Acid and Absorption
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.

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Sackett & Sons Co., The A. J., Baltimore, Md.

UREA
DuPont de Nemours & Co., E. I., Wilmington, Del.

UREA-AMMONIA LIQUOR
DuPont de Nemours & Co., E. I., Wilmington, Del.

VALVES—Acid-Resisting
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
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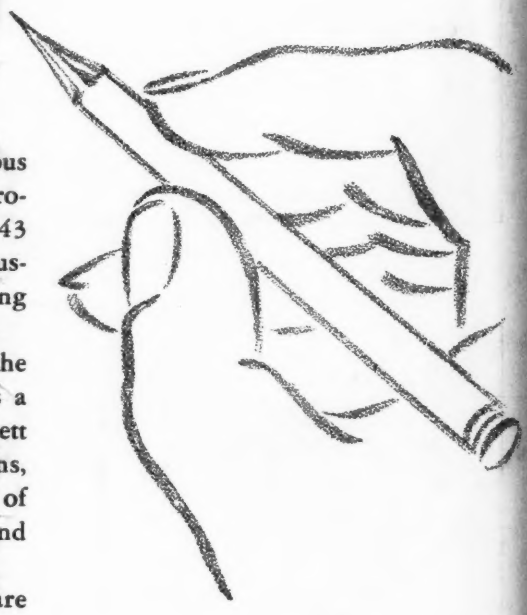

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